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Constraining Soil Freezing Models using Observed Soil Freezing Characteristic Curves

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Objective: Estimate Soil Freezing Characteristic Curves (SFCCs) and uncertainty bounds based on a compilation of existing measured SFCCs.

Key Findings

- Uncertainty in measured SFCCs is estimated based on measurement technique, water content, and soil disturbance
- An open-source tool for estimating and constraining SFCCs is developed for use in parameterizing freeze/thaw models

Abstract

Cold-regions landscapes are undergoing rapid change due to a warming climate. This change is impacting many elements of the landscape and is often controlled by soil freeze/thaw processes. Soil freeze/thaw is governed by the Soil Freezing Characteristic Curve (SFCC) that relates the soil temperature to its unfrozen water content. This relation is needed in all physically based numerical models including soil freeze/thaw processes. A repository of all collected SFCC data and an R package for accessing and processing this data was presented in "A Repository of 100+ Years of Measured Soil Freezing Characteristic Curves".

This rich SFCC dataset is synthesized with a focus on potential sources of error due to the combination of measurement technique, data interpretation, and physical freeze-thaw process in a specific soil. Particular attention is given to combining sources of error and working with datasets given incomplete and missing metadata. A tool is developed to extract an SFCC for a soil with specified properties alongside its uncertainty bounds. This tool is intended for use in freeze/thaw models to improve freeze/thaw estimates, and better represent the ice and liquid water content of freezing soils. As phase change accounts for a vast majority of the energy budget in freezing soils, accurately representing the process is essential for realistic predictions. In addition, SFCC type curves are provided for the common sand, silt, clay, and organic soil textures when additional data is unavailable to define the SFCC more precisely.